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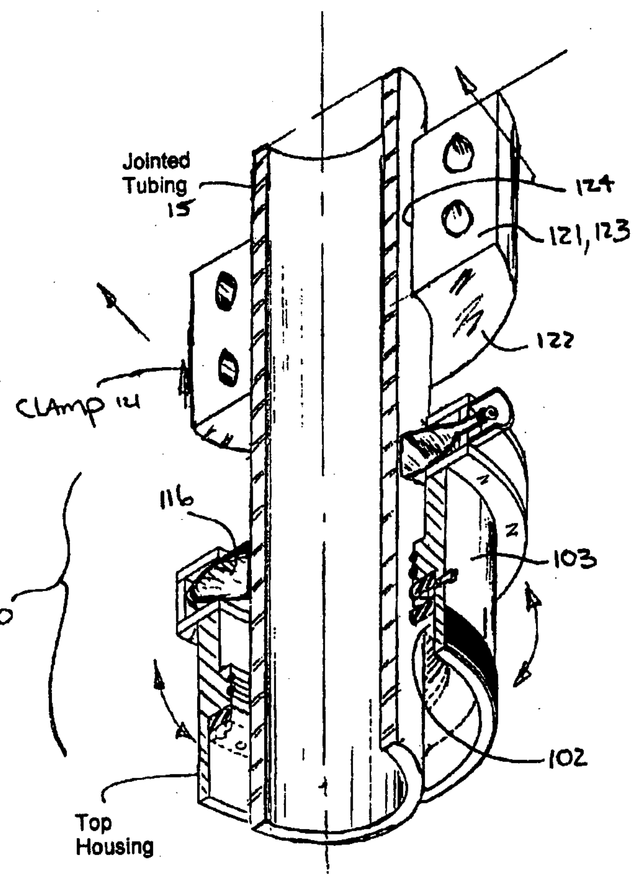
(54) INSTALLATION DE FORAGE A TIGES HELICOIDALES
(54) COILED TUBING DRILLING RIG



(57) A novel rotary table is secured to the top of a well's BOP simplifying the making up of sectional tubing joints used in some aspects of operations with coiled tubing. The rotary table comprises top a bottom stationary housing affixed to the BOP, a top housing supported on the bottom housing by an annular bearing, a split clamp to transferring the weight of the tubing to the top housing and seals between the top and bottom housings and between the top housing and the tubing. More preferably, a coiled tubing rig is provided having a frame, a tiltable mast, an injector reel, a tubing straightener and a jib crane in combination with the rotary table for increased functionality including drilling surface hole using coiled tubing. The mast tilts between two positions, either aligning coiled tubing and injector with the BOP or aligning a jib crane and tubing elevators for manipulating sectional tubing including BHA onto and through the rotary table.

"COILED TUBING DRILLING RIG"

FIELD OF THE INVENTION

The present invention relates to apparatus and a process for drilling a well. More specifically, coiled tubing is used for drilling a borehole in the earth.

BACKGROUND OF THE INVENTION

The general background relating to coiled tubing injector units is described in U.S. Patent No. 5,839,514 and 4,673,035 to Gipson which are incorporated herein by reference for all purposes.

Coiled tubing has been a useful apparatus in oil field operations due to the speed at which a tool can be inserted and tripped out of a well bore. Coiled tubing is supplied on a spool. An injector at the wellhead is used to grip and control the tubing for injection and withdrawal at the well. Accordingly, it is known to connect a bottom hole assembly ("BHA") to the bottom of the coiled tubing and run it into the well bore using the injector. A BHA may include measuring and sampling tools, each of which are threaded together in series and which may also include drill collars and the like for weight purposes. Further, use of downhole motors and coiled tubing became more popular when drilling deviated wells as it made more sense to limit drilling rotation to the bit and not the entire string.

As stated, coiled tubing has more recently become a contender in the drilling industry, due to the potential to significantly speed drilling and reduce drilling costs through the use of continuous tubing. The most significant cost saving factors

include the reduced pipe handling time, pipe joint makeup time, and reduced leakage risks.

In spite of the significant potential cost savings through the use of coiled tubing, there are certain aspects of the associated apparatus and process which have limited its drilling applications.

Coiled tubing has been unable to cope with all stages of the drilling and have required the assistance of conventional jointed tubing rigs. For example, coiled tubing has not been successfully used to drill surface hole due in part to a lack of bit weight at surface or shallow depths, lack of control over the coiled tubing's residual bend and the generally uneven surface materials at surface, such as glacial residue. Typically then, a separate and conventional rig comes in to drill surface hole and place surface casing. Once the surface casing is in place and cemented, coiled tubing is used to re-enter the surface hole to deepen it over a relatively short distance (i.e., coiled tube drilling only the last and smallest portion). Another application for coiled tubing is to re-enter a vertical hole to drill relatively short horizontal laterals. Further, after drilling, a separate rig is brought in to run in the production casing.

The limited applications for coiled tubing are thought to be the result of several problems which are normal and expected when using coiled tubing. One set of problems is related to the inability to rotate coiled tubing. A conventional rotary drilling rig rotates the entire drill string from the surface for rotating a rotary drill bit downhole. The continuous coiled tubing is supplied from a spool at surface and cannot be rotated. Accordingly, a BHA including a downhole motor and drill bit is

connected to the bottom end of the coiled tubing. Further, the BHA is typically threaded together and thereby results in a laborious threading of the multiple components separate from the coiled tubing. It is sometimes desirable to increase the weight on the bit early in the drilling and thus a few lengths of conventional drill collars might be to threaded onto the BHA.

The injector is typically located at the wellhead and must be set aside to permit the larger diameter BHA to be placed through the wellhead and into the hole. Further, when running, the wellhead injector tends to inject tubing which has residual bend therein. As one can imagine, a residual bend can result in added contact and unnecessary forces on the walls of the hole, resulting in increased frictional drag and an uncentered position of the tubing within the hole. Occasionally the coiled tubing wads up in the hole (like pushing a rope through a tube) and cannot be injected any further downhole or ever reach total depth.

Therefore, in practice, the above problems result in the need for multiple rigs; a conventional rig to drill and place surface casing, coiled tubing for the remainder of the drilling and a conventional rig again to place the production casing. Besides the duplicity for much of the equipment and personnel, much time is lost in assembling the BHA.

For example, a conventional rig may take two days to spud in, drill surface casing, and cement the casing. The crew manually makes up a BHA, requiring in the order of 6 hours. A separate crane is generally employed to lower the BHA through the wellhead, the BHA being supported temporarily on slips. If weight is required, one or more drill collars are manually threaded into the BHA

supported at the wellhead. Finally, a prior art coiled tubing rig is set up and connected to the BHA, injected down the surface casing and drilling may then begin. After drilling, the crane is again employed to withdraw the BHA from the well. Lastly a conventional rig is brought in again to place the jointed production casing.

Coiled tubing rigs, while faster, have a much higher capital cost and operating cost. The repeated plastic deformation of the coiled tube means it must be replaced often to avoid failure. The relatively small diameter coiled tubing requires greater fluid horsepower to deliver mud to the downhole motor.

Thus, it is an objective to use the coiled tubing rig for a greater portion of the on-site operations, reduce the on-site time generally and improve the drilling process.

SUMMARY OF THE INVENTION

A novel combination of components has resulted in a novel coiled tubing rig capable of superior handing and drilling. In a preferred embodiment of the invention, the coiled tubing rig is provided having a frame, a mast pivotally mounted from the frame, and atop the mast, an injector reel, reel drive, a tubing straightener and a jib crane. The addition of a novel rotary table to the BOP markedly enhances the capabilities and operation this already versatile coiled tubing drilling rig.

Once spudded in and surface casing is placed, the preferred coiled tubing rig, can drill 1100 meters of hole and have production casing including cement in about 16 hours, faster that a conventional rig by about 24 – 30 hours.

Once set up over the wellhead, the novel rig's mast can be tilted between two positions, one to align the injector with th wellhead and a second to tilt the injector out of alignment and permit the jib crane to align with the wellhead. The injector is mounted high above the tubing and thus can accept long lengths of BHA, threaded tubular components or other jointed sections between the wellhead and coiled tubing. A stabilizer ensures that the straightened tubing is directed into the wellhead. Further, for further speeding the make up of the BHA, the rotary table is provided on the wellhead which support the jointed BHA sections so that they are easily rotated while supported at the wellhead to make up threaded joints. The addition of power tongs to the jib crane and tilting of the mast enables jointed production casing to be quickly run in without need for another rig.

As a result of the above combination, the preferred coiled tubing rig is able to drill surface hole, place jointed surface casing, quickly make up jointed BHA, drill the well bore, withdraw the coiled tubing, quickly remove the BHA, and place jointed production casing.

In one aspect of the invention, surface hole can now be drilled due to the combination of providing an injector high above the wellhead, an intermediate straightener which ensures that the tubing is straight and a stabilizer tube above the wellhead. The preferred injector is capable of up to 15,000 lb. force and it with PDC bits (polycrystalline diamond compact, typically needing only about 9,000 lbf) may not even be necessary to use additional drill collars for weight. Drill collars may yet be added for stabilization to aid in keeping the surface hole straight.

In another aspect of the invention, apparatus is provided which can be added to any coiled tubing rig which aids the making up of joint d sections such as the BHA and drill collars. A rotating table is provided which is mounted atop the blowout preventor (BOP) of a wellhead. The rotary table comprises top and bottom housings having a contiguous bore therethrough and an annular bearing installed therebetween. Conventional jointed sections can be passed through the housings' bore and down through the wellhead. A support is installed to grip the jointed section and has a bottom surface for transmitting the weight of the gripped jointed sections through the top housing and into the annular bearing. Thus, the jointed sections are prevented from being lost downhole yet are easily rotated on the annular bearing for making up successive threaded joints. It has been found that usual BHA make up time of about 6 hours can now be accomplished in about 0.5 – 1.0 hours.

Rather than use a separate crane to lift and lower long lengths (e.g. 30 feet long) BHA through the rotary table, a jib crane extension is provided to the coiled tubing rig.

To enable alignment of the BHA over the wellhead, the coiled tubing rig injector must be movable out of its working alignment from the wellhead. Accordingly, the mast is pivotable adjacent the wellhead so as to tilt the mast out of the way and permit the jib crane access to the wellhead.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side el vation view of the coiled tubing aspect of the apparatus, illustrated in a road transport mod , and constructed according to an embodiment of the present invention

Figure 2 is an overall side elevation view of the apparatus according to Fig. 1, arranged over a well bore in an injecting/drilling position;

Figure 3 is a close up side elevation view of the mast and injector according to Fig. 2;

Figure 4 is a side elevation view of the apparatus according to Fig. 3, wherein the mast is tilted out of alignment from the wellhead for handing lengths of tubing and BHA;

Figures 5 is a partial side and exploded views of the bottom housing incorporated into the flow tee. The flow tee is flanged to the BOP and the top housing is separated from the bottom housing;

Figures 6 is an upward perspective sectional view of a jointed section (pipe) passing through the rotary table's top housing. The pipe is fitted with a split clamp, both of which are ready to set down on the top housing for rotary capability;

Figures 7a – 7d are a variety of upward perspective views of the top housing. Specifically,

Fig. 7a is a view of the top housing;

Fig. 7b is a sectional of the top housing, illustrating the installation of the ring bearing;

Fig. 7c is an exploded view of the three components of the rig bearing;

Fig. 7d is a view of an elastomeric seal for installation into the entrance of the top housing for sealing about a jointed section passing therethrough;

Figures. 8a and 8b are views of the top housing. Specifically,

Fig. 8a is a side sectional view of the top housing with the ring bearing installed; and

Fig. 8a is a top view of the top housing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Having reference to Fig. 1, a coiled tubing injector is mounted on a mobile deck such as a truck or trailer or on a separate frame (not shown) which could be slid or lifted onto or off of a truck or trailer.

As disclosed in US Patent 5,839,514 to Gipson, a coiled tubing storage reel or spool 18 is mounted on a cradle 20, and coiled tubing 22 is stored thereon. The cradle 20 is attached to a traversing mechanism which allows the cradle 20 to be reciprocated perpendicularly to the axis of the frame 12.

A reel 34 is rotatably attached to one end of boom arm or mast 38. Mast 38 is attached at hinge member 40 to mast riser 42. Mast riser 42 is attached to the back end 44 of frame 12. The injector reel 34 is positioned at he top of the frame 12.

Injector reel 34 is further provided with a drive mechanism 46 which includes a hydraulic drive motor 48, a drive chain linkage 50, and sprocket assembly 52 extending circumferentially around the injector reel 34.

Reel support frame 190 also extends circumferentially around the reel 34 and supports a straightener assembly 54 and a hold down assembly 56.

Hold-down assembly 56 consists of a multiplicity of separate hold down mechanism 58. Twenty hold-down mechanisms are mounted around a portion of the circumference of the injector reel 34 to exert pressure against the coiled tubing over more than 90 degree of the injector reel circumference.

The straightener applies unequal pressure against the coiled tubing, plastically altering the curve of the coiled tubing so that it leaves the strightener as linear tubing, without any residual curve.

A hydraulically activated elevating work floor 59 is movable along the working length of the mast and particularly adjusts for variable classes of BOP which can vary up to 2 meters in final installed height.

In a first position, the mast 38 raised by a mast lift cylinder 64, pivoting about hinge 40, to a tubing injection position generally perpendicular to the frame 12. Swing locks 62 (one on each side of mast 38) are latched to secure the mast 38 and injector reel 34 in the uplift position. In the first injecting position, coiled tubing 22 extends from the storage spool 18 up and over the injector reel 34. The hold-down assembly 56 extends around a portion of the circumference of the injector reel to exert pressure on the coiled tubing as it is straightened and injected into the well or returned to the spool.

When the embodiment is in the injecting position tubing 22 exits the injector reel 34 generally perpendicular with the ground. In cases where the apparatus is past the surface casing stage, the tubing 22 exits the injector reel 34

generally aligned with the w llhead. The wellhead typically includes a blowout preventor or BOP 74.

A telescoping tubing stabilizer 70 has an upper section 71 and a lower section 72. The stabilizer 70 extends between the straightener assembly 54 and the BOP 74 at the wellhead. The function of the stabilizer 70 is to ensure that the coiled tubing 22 does not bend or excessively flex as it is being injected.

The mast is fitted with a jib and hoist. The hoist has a travelling block, and elevator bales for lifting lengths of casing, tubing, etc.

Having reference to Figs. 5 – 8b, mounted atop the BOP 74 is a rotary table which comprises top and bottom housing, spaced apart by a ring bearing. As shown in Fig. 5, the bottom housing is incorporated into a flow tee. Generally, the flow tee or nipple is positioned directly above the BOP. The top and bottom housings have a bore which is complementary to the BOP and wellhead, suitable for passing the coiled tubing and also jointed sections such as the BHA.

The bottom housing comprises an upstanding sleeve having an intermediately located and radially outward projecting annular bottom shoulder. The top housing has an downward sleeve and an intermediately located inwardly projecting annular top shoulder. The upstanding sleeve of the bottom housing fits closely through the top shoulder. The downward sleeve of the top housing fits closely through the bottom shoulder. O-Ring seals at the nose of each of the top and bottom shoulders seal against the bottom and top housings sleeves respectively.

The ring bearing is sandwiched between the top and bottom annular shoulders, permitting the top housing to rotate freely on the bottom housing.

The top housing is retained to the bottom housing using a threaded collar located below the bottom shoulder. When threaded onto the top housing's sleeve, the collar pulls the top housing onto the bottom housing, loading the ring bearing therebetween.

The ring bearing is sectional comprising a top race, a bottom race and an intermediate cage ring fitted with a multiplicity of ball bearings. The bottom race is supported by and rests on the bottom shoulder. The cage ring rests on the bottom race and the top race bears against the cage race.

The top housing provides a general service rotary section supported on the ring bearing for rotation about the vertical axis 20 of the wellhead. The rotary section further incorporates or supports means for controllably and periodically gripping the jointed sections while operations are performed.

The gripping means are typically a slip arrangement or a split clamp. When the gripping means is secured about the jointed section, the gripping means is lowered into engagement with the top housing or rotary section so that it bears against the top race and transmits the weight of the jointed section into the wellhead while permitting it to rotate.

Typically, it is inconvenient to access the end of the jointed section to apply the gripping means. Accordingly, the gripping means can be applied to support at the mid-point of a length of tubing.

One conventional form of gripping means include a plurality slip type gripping units (not shown). Circularly spaced wedge slips have outer tapering surfaces which engage correspondingly tapered surfaces of the rotary section to cam the slips inwardly in response to downward movement thereof. The inner gripping faces of the slips are formed with teeth or other irregularities adapted to engage the outer surface of the jointed section to transmit tubing weight into the rotary section and support it in the well.

Another form of rotary section gripping means is a split clamp having a cylindrical body split diametrically in half. The two body halves have facing semicircular recesses or gripping surfaces and are positioning on either side of the tubing to be supported. The two body halves are sized so that when clamped about tubing, they do not bottom against each other, the diametral depth of their combined recesses being less than the diameter of the jointed section.

As shown in Fig. 6, when clamped about the tubing, the two body halves combine to become the cylindrical body of the split clamp which then rests upon the top housing.

A BHA can now be made up by supporting each jointed section through the wellhead, supported by the split clamp and top housing and be rotated while using chain tongs to tighten the joints. Further, the completed and heavy BHA can be rotated freely and supported on top housing so as to thread it onto the connection to the non-rotating coiled tubing.

THE EMBODIMENTS OF THE INVENTION FOR WHICH AN EXCLUSIVE PROPERTY OF PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A rotary table for the supported rotation of sectional tubular components which extend through a bore in a wellhead comprising:

(a) a bottom stationary housing affixed to the top of the wellhead and having a bore contiguous with the wellhead;

(b) a top rotational housing having bore a contiguous with the bottom housing;

(c) means for transferring the weight of the components to the top housing;

(d) an annular bearing installed between the top and bottom housings for rotationally supporting the weight of the components and having bore contiguous with the top and bottom housings;

(e) a seal between the top and bottom housings; and

(f) a seal between the top housing and the components passing therethrough so that the components can be rotationally supported through the wellhead, the wellhead seal is maintained and the components can be rotated.

2. The rotary table of claim 1 wherein the means for transferring the weight of the components to the top housing is a split clamp.

3. The rotary table of claim 2 wher in:

(a) the bottom housing has an upward tubular protub rance formed with an annular and radially outwardly extending shoulder upon which the annular bearing is supported; and

(b) the top housing has an annular shoulder extending radially inwardly from the bore so that, when the top housing is telescoped over the protuberance, the inward shoulder bears against and is supported on the annular bearing.

4. The rotary table of claim 3 wherein:

(a) the protuberance's shoulder is fitted with a circumferential outer seal for sealing against the bore of the top housing; and

(b) the top housing's shoulder is fitted with a circumferential inner seal for sealing against the protuberance.

5. The rotary table of claim 4 further comprising means for retaining the top housing to the bottom housing.

6. The rotary table of claim 5 wherein the retaining means comprises an annular collar rotatably fitted between the wellhead and the protuberance's shoulder, the collar extending about the protuberance's shoulder to engage the top housing and draw the top housing to the bottom housing, retaining them together.

7. The rotary table of claim 6 wherein the annular collar has female threads for engaging male threads on the top housing.

8. The rotary table of claim 4 wherein flow tee is incorporated into the bottom housing.

9. Hybrid apparatus for operation with both coiled and sectional tubing apparatus comprising:

(a) a coiled tubing rig having a frame and a mast normally aligned over a wellhead, an injector located in the mast and a tubing straightener positioned between the injector and the wellhead;

(b) a rotary table affixed to the well head for rotationally supporting sectional tubular components passing through the wellhead;

(c) a jib crane mounted atop the mast; and

(d) means for pivoting the mast between two positions,

(i) a first position where the mast, injector and straightener are aligned with the wellhead for injection and withdrawing of coiled tubing, and

(ii) a second position with the mast pivoted out of alignment from the wellhead so that the jib crane can align sectional tubing with the wellhead and be supported therefrom and be made up on the rotary table.

10. The hybrid apparatus of claim 9 wherein the sectional tubing is a BHA.

11. The hybrid apparatus of claim 10 further comprising power tongs for enabling sectional production casing to be quickly made up and run in through the wellhead.

12. A method of drilling a well using coiled tubing comprising the steps of:

(a) providing a rotary table over the well;

(b) standing tubular sections on the rotary table to enable rotation of adjacent sections for making up a drilling assembly including a downhole motor and drill bit;

(c) aligning a coiled tubing injector over the drilling assembly;

(d) rotating the drilling assembly to make up to the coiled tubing; and

(e) drilling the well through the rotary table.

13. The method of claim 12 further comprising:

(a) spudding a well with a conventional drilling rig and installing a wellhead; and

(b) fitting the rotary table to the wellhead.

14. The method of claim 13 wherein the drilling assembly comprises a BHA.

15. The method of claim 14 further comprising;

(a) positioning a coiled tubing rig over th well, the rig having a mast with a jib crane, an injector being mounted in the mast's top with a straightener mounted between the injector and the well;

(b) moving the injector and straightener out of alignment for lifting tubular sections and standing them on the rotary table for making up the drilling assembly; and

(c) moving the injector and straightener into alignment with the rotary table for making up the drilling assembly to the coiled tubing.

16. Hybrid apparatus for operation with both coiled and s ctional tubing apparatus comprising:

(a) a coiled tubing rig having a fram and a mast normally aligned over a wellhead, an injector located in the mast and a tubing straightener positioned between the injector and the wellhead;

(b) a rotary table affixed to the well head for rotationally supporting sectional tubular components passing through the wellhead;

(c) a jib crane mounted atop the mast; and

(d) means for pivoting the mast between two positions,

(i) a first position where the mast, injector and straightener are aligned with the wellhead for injection and withdrawing of coiled tubing, and

(ii) a second position with the mast pivoted out of alignment from the wellhead so that the jib crane can align sectional tubing with the wellhead and be supported therefrom and be made up on the rotary table.

ABSTRACT OF THE INVENTION

A nov l rotary table is secured to the top of a w ll's BOP simplifying the making up of sectional tubing joints used in some aspects of operations with coiled tubing. The rotary table comprises top a bottom stationary housing affixed to the BOP, a top housing supported on the bottom housing by an annular bearing, a split clamp to transferring the weight of the tubing to the top housing and seals between the top and bottom housings and between the top housing and the tubing. More preferably, a coiled tubing rig is provided having a frame, a tiltable mast, an injector reel, a tubing straightener and a jib crane in combination with the rotary table for increased functionality including drilling surface hole using coiled tubing. The mast tilts between two positions, either aligning coiled tubing and injector with the BOP or aligning a jib crane and tubing elevators for manipulating sectional tubing including BHA onto and through the rotary table.

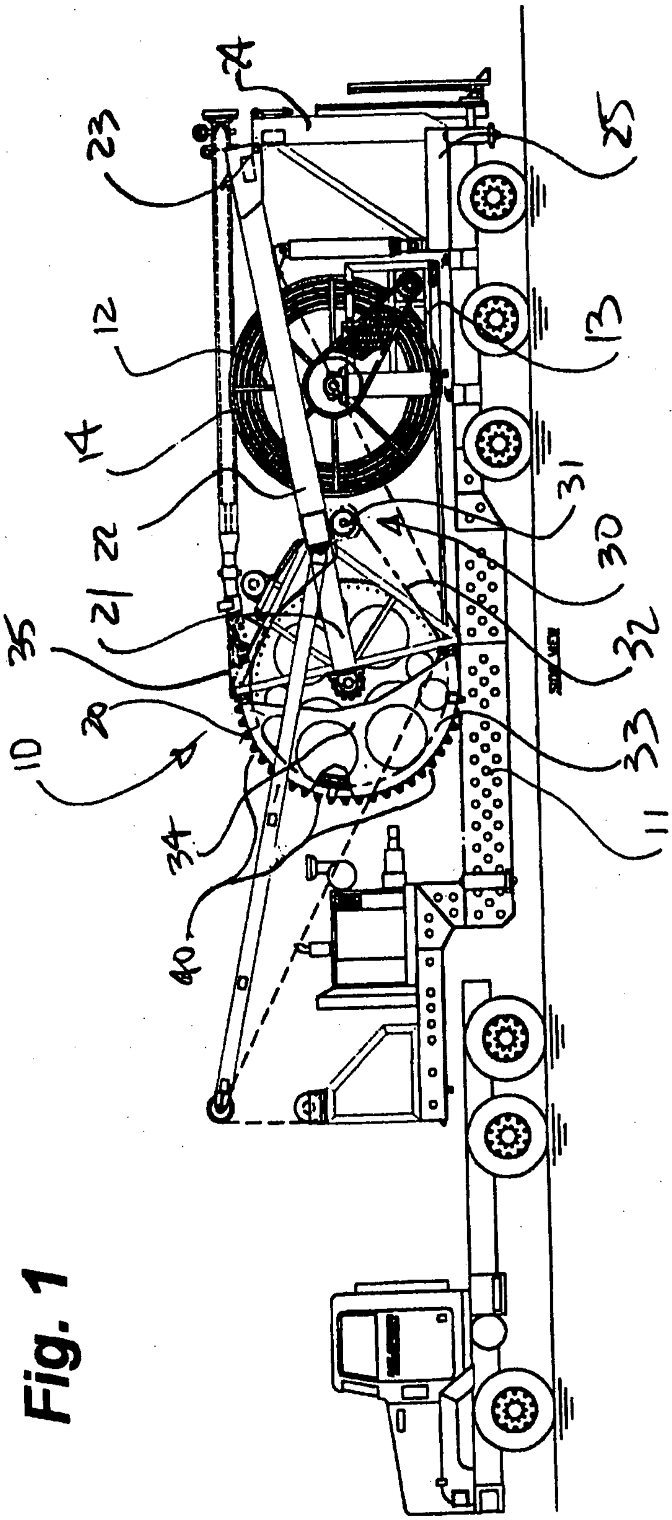


Fig. 1

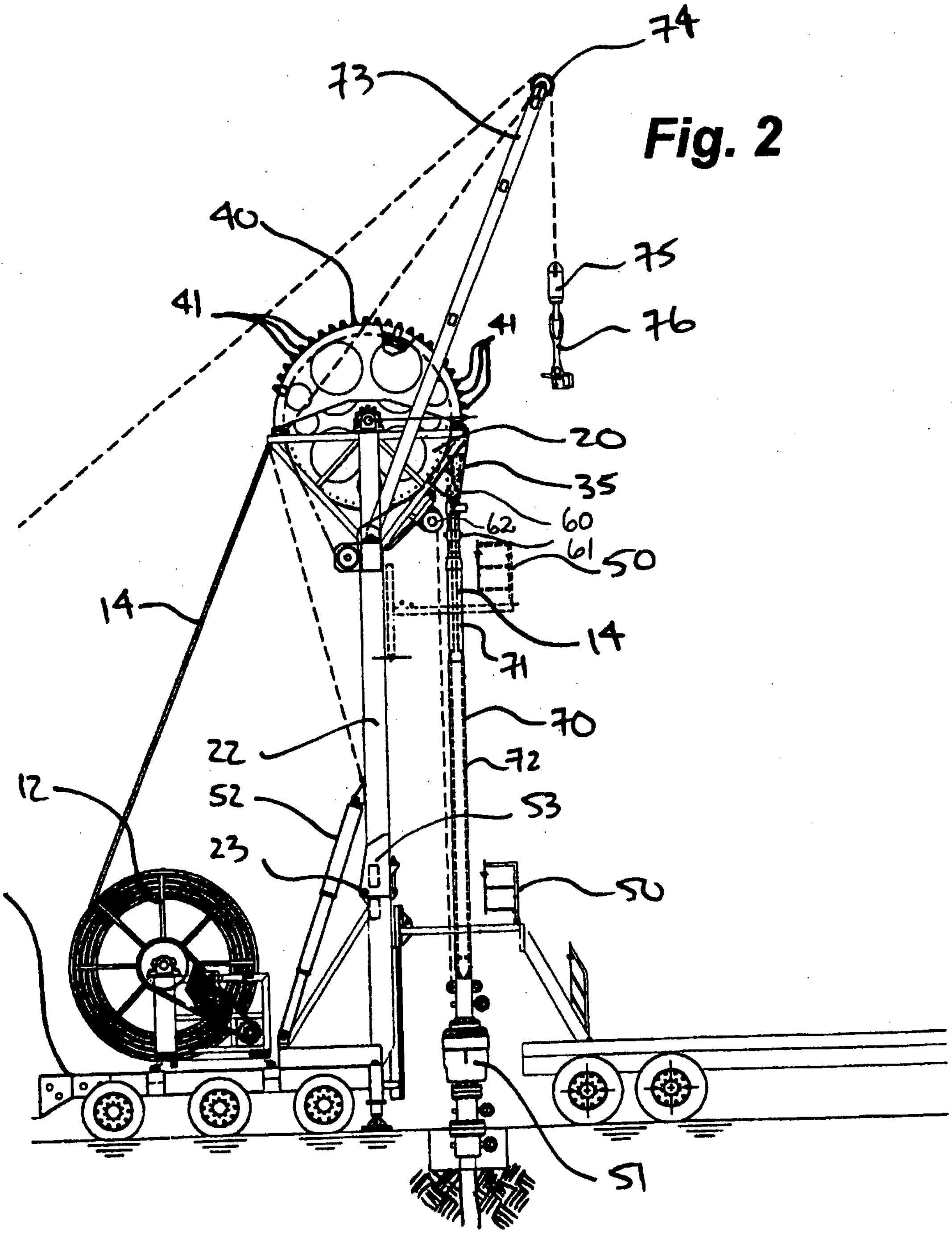


Fig. 2

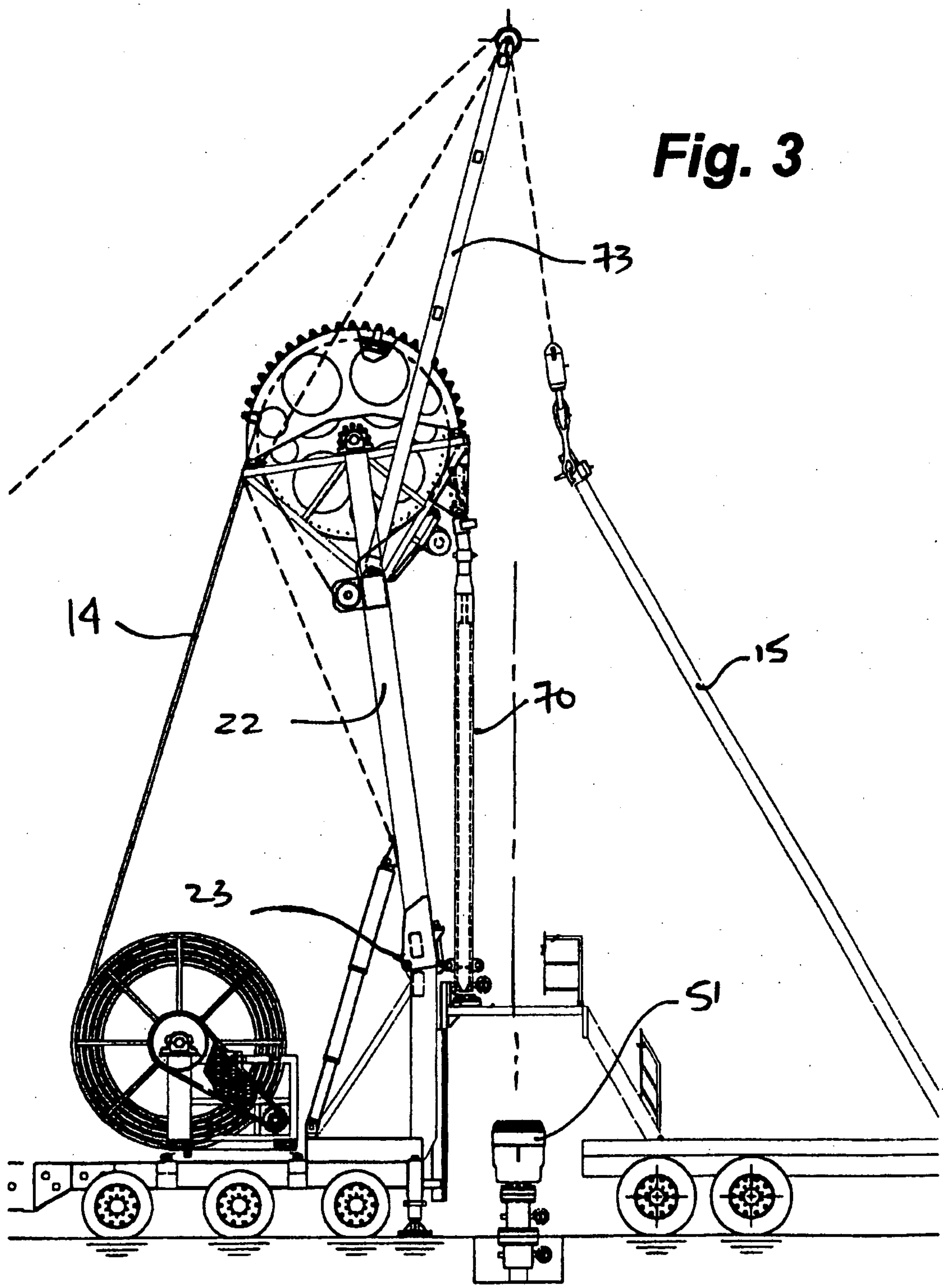
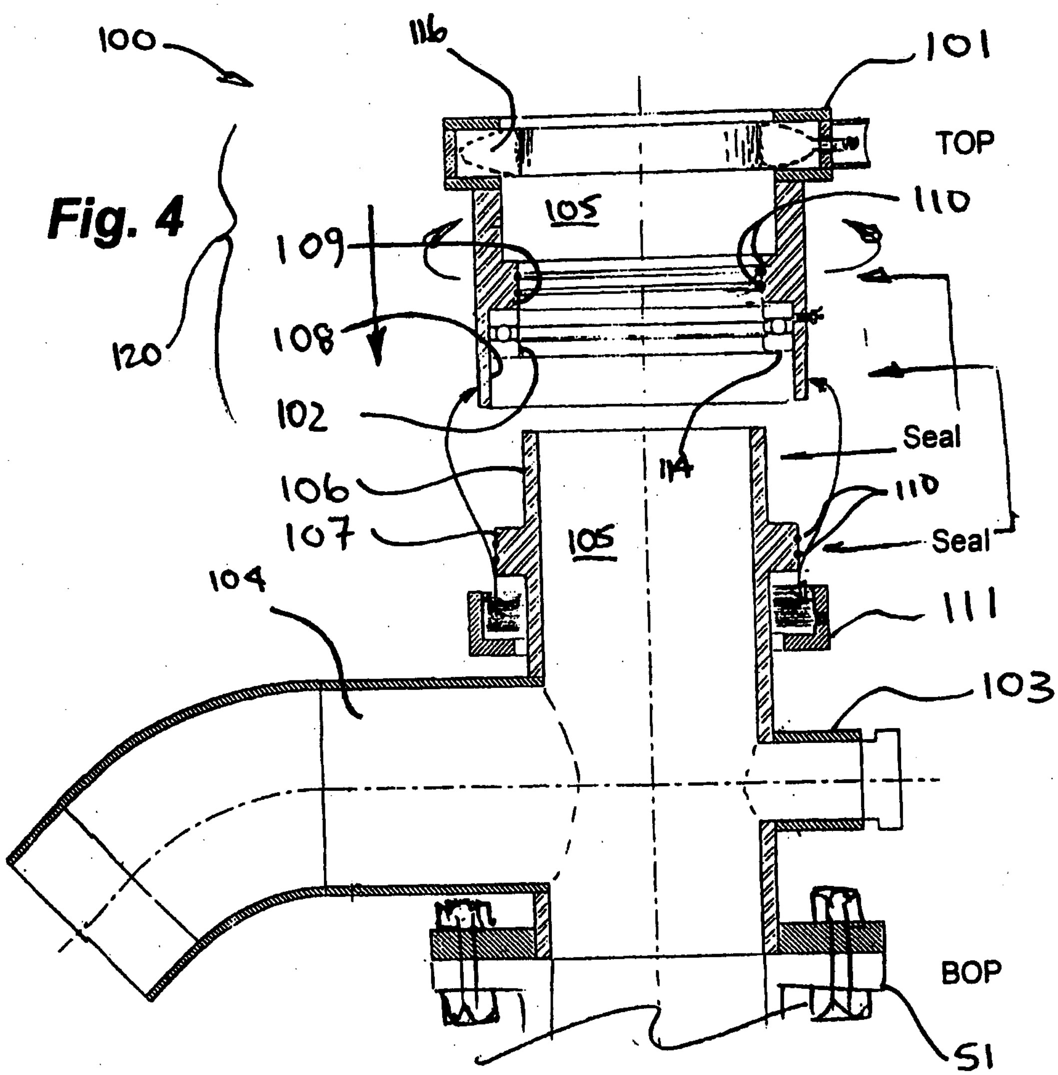


Fig. 3



100
116
101
TOP
Fig. 4
105
110
109
108
120
102
114
Seal
106
110
107
105
Seal
104
111
103
BOP
51

Fig. 5

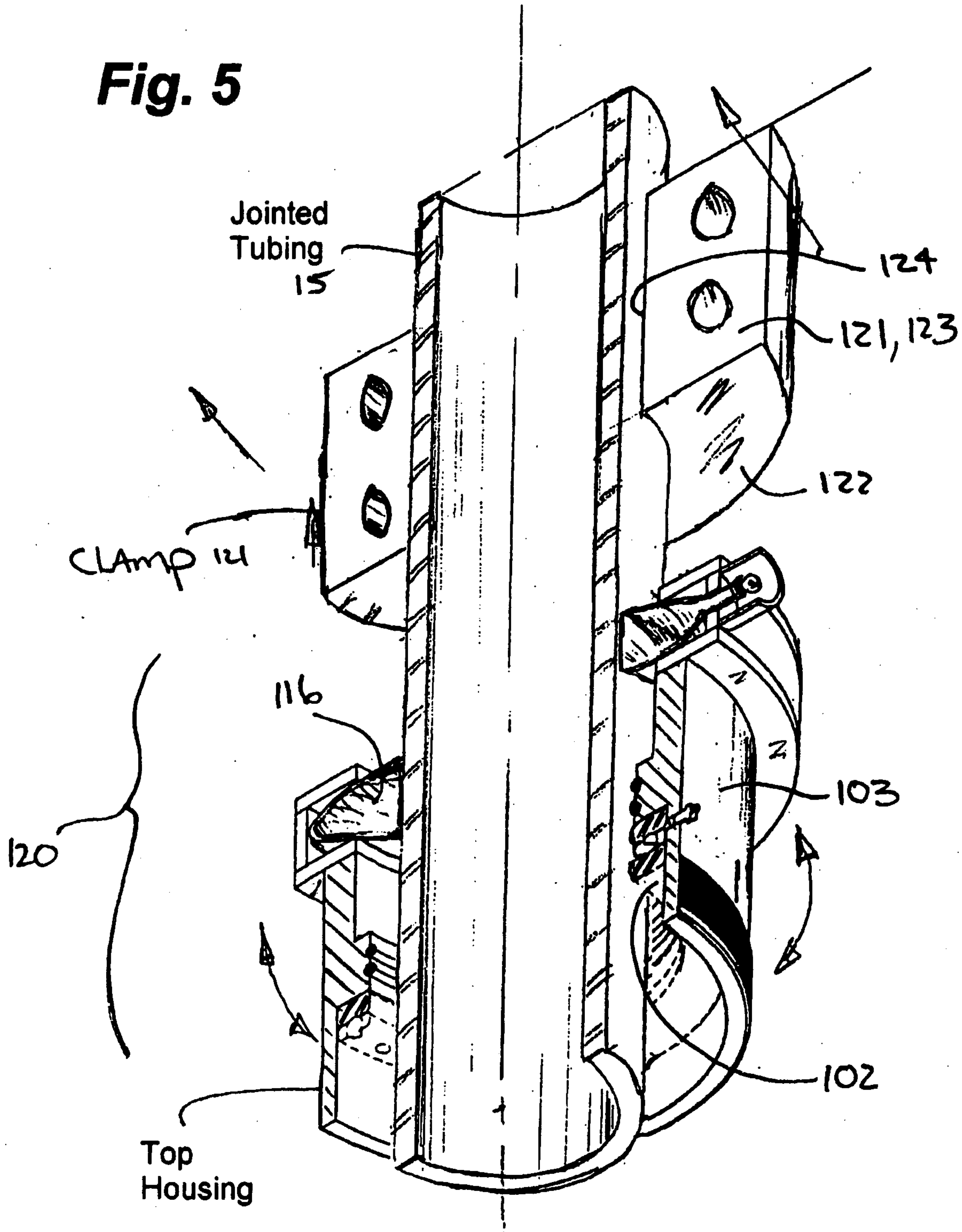
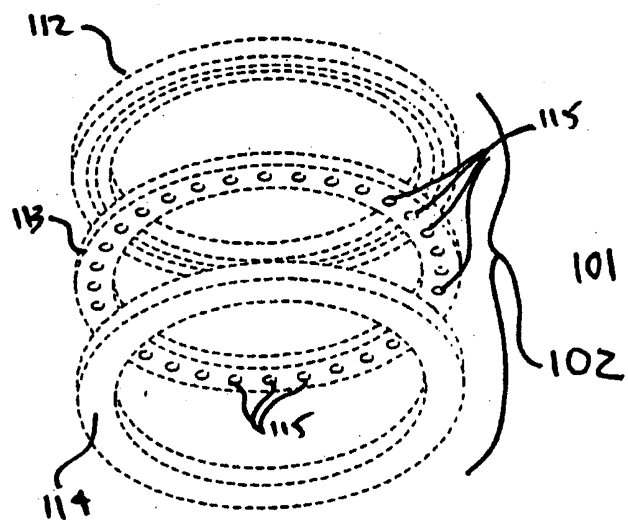
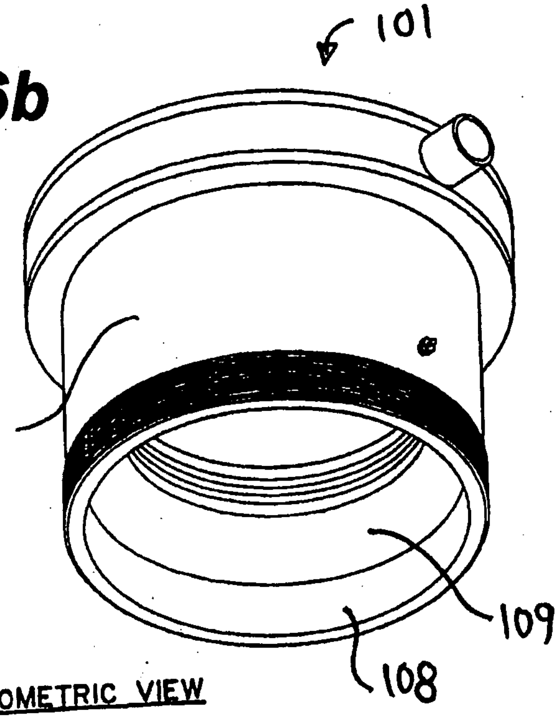

Jointed
Tubing
15
124
121, 123
122
CLAMP 121
116
103
120
102
Top
Housing

Fig. 6a



3 PIECE BEARING

Fig. 6b



ISOMETRIC VIEW

SEAL-O-GRIP TUBE

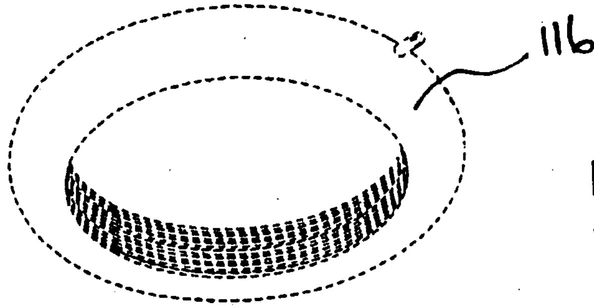


Fig. 6c

ISO SECTION VIEW 'A'

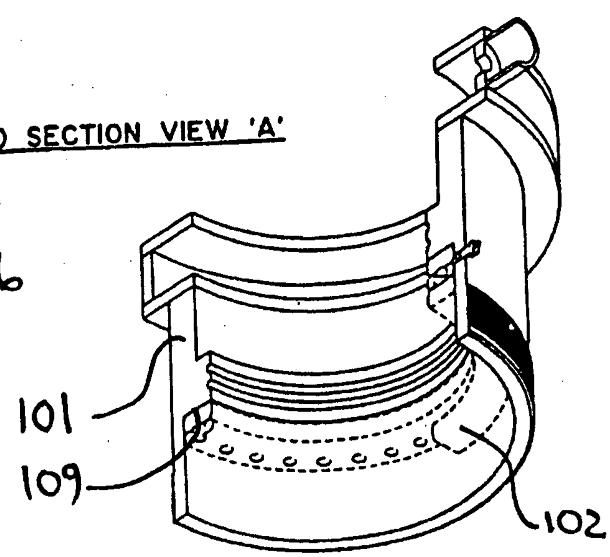


Fig. 6d

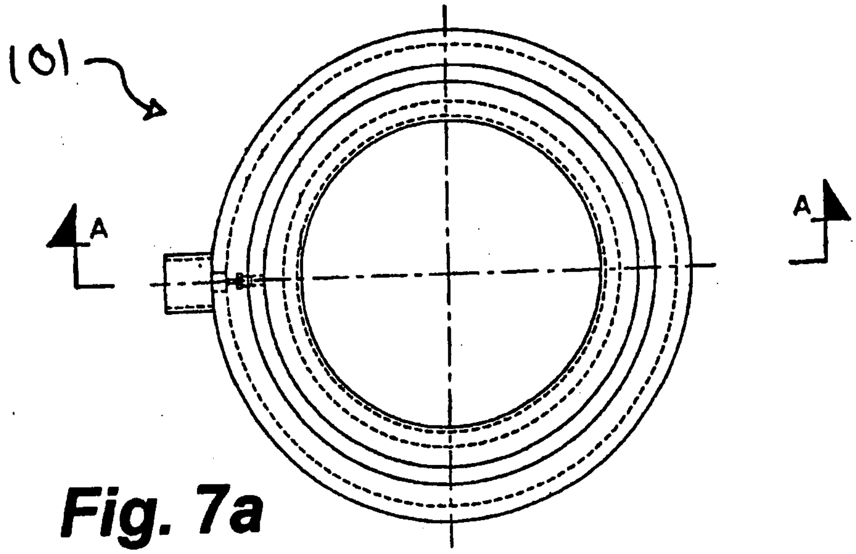


Fig. 7a

Top View

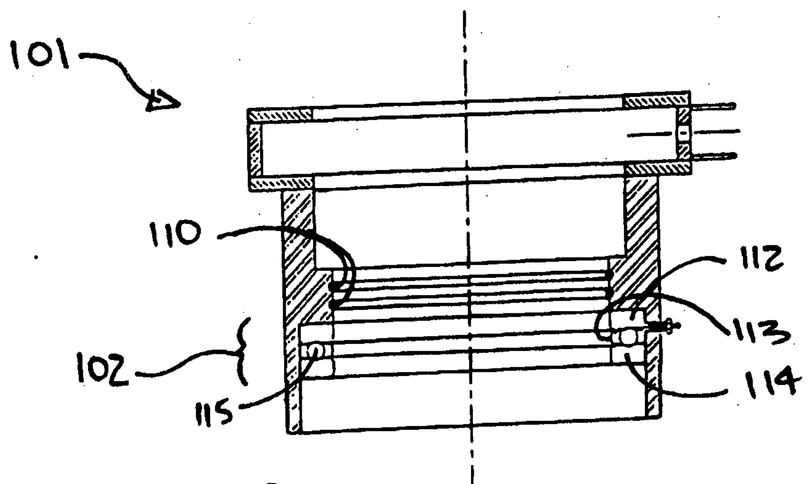


Fig. 7b Sectional View A-A